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Research paper

Cooperative GPS and Neighbors Awareness Based Device Discovery for D2D Communication in in-Band Cellular Networks

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Abstract

Device to Device (D2D) communication is a new paradigm for next-generation wireless systems to offload data traffic. A device needs to discover neighbor devices on the certain channel to initiate the D2D communication within the minimum period. A device discovery technique based on Global Positioning System (GPS) and neighbor awareness base are proposed for in-band cellular networks. This method is called network-centric approach, and it improves the device discovery efficiency, accuracy, and channel capacity. The differential code is applied to measure the signal to noise ratio of each discovered device. In the case that the signal to noise ratio (SNR) of two devices is above a specified threshold value, then these two devices are qualified for D2D communication. Two procedures are explored for device discovery; discovery by CN (core network) and eNB (evolved node B) cooperation with the help of GPS and neighbor awareness. Using 'Haversine' formula, SNR base distance is calculated. Results show an increment in the channel capacity relative to SNR obtained for each device.

Keywords: *D2D Communication; SNR, GPS; CN; and eNB*

1 Introduction

Due to spectrum crises and its high vitality utilization wireless and mobile networks planners have been confronting the consistently expanding interest for high data rates and versatility needed by new wireless applications. In this manner, research has been begun on 5th generation wireless frameworks that are probable to be implemented beyond 2020 (1). One of the techniques to implement 5G is to shift the intelligence at the device level. Device to Device (D2D) Communication is one of the potential advancements in 5G. In D2D communication, two devices communicate directly without passing through the intermediate node as shown in Figure 1. Up to 4G wireless cellular networks, D2D communication practicality has not been considered (2).

The very important advantages of direct D2D communication, source devices may enjoy data rates, minimum delay, and energy efficiency. Along with that direct D2D communication alleviate congestion from the main network (3), (4). This is because it has primarily been imagined as a device level communication to minimize the expense of nearby service locating. Service providers can further exploit D2D effectiveness in a stadium or shopping center where a huge number of users use mobiles and share information. Their direct transmission among intelligent devices and different wireless nodes will minimize the congestion in the network. Moreover, D2D communication can be utilized in public safety networks, disaster as in a quake or sea tempest. A temporary communication system can be set up utilizing D2D effectiveness as a part of a system by replacing the damaged communication system and internet arrangement (5).

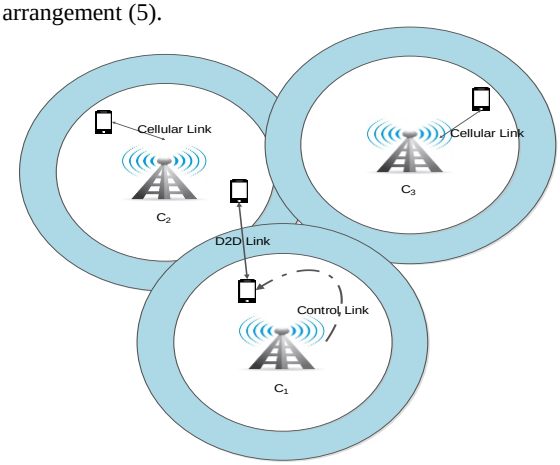


Fig. 1: D2D communication in multicell

In D2D communication layout, devices most of the time is contact probing for a partner and start communication when partner found. Energy can be saved when devices start communication and data sharing when they are the vicinity of each other. Contact probing also is slightly energy consuming as results are validated in (6). Initiating D2D communication starts with the device discovery (7) and followed by the access process. Each discovered device acts as a femtocell and fully or partially controlled by the cellular network. Cooperative use of Global Positioning System (GPS), and neighbor

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awareness can help for efficient discovery and minimum energy consumption. These new transmission standards guarantee the noteworthy gain performance of capacity, spectral efficiency, and reliability. Many researchers present many techniques for device discovery for out-band D2D communication like in Wi-Fi, Zig-Bee, and Bluetooth but in-band discovery research is very limited (8). However, this work focuses on in-band D2D discovery. It is a big challenge due to efficient device discovery in term of energy, latency, and multicell scenarios. When the devices start the discovery process, is called a self-organized discovery (9). On the other hand, if particular devices are discovered by the network, the process is called a network-assisted device discovery, as shown in Figure 2.

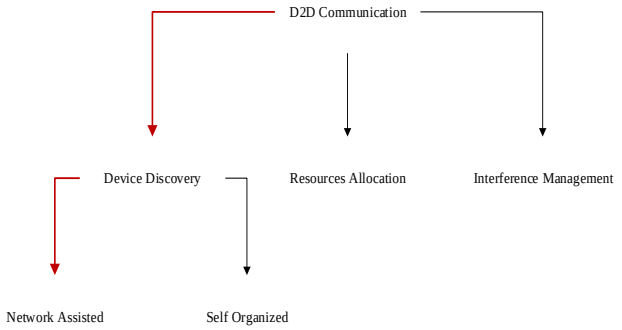


Fig. 2: Main challenges in D2D communication

The positioning of sources and individuals using GPS is becoming a progressively standard. GPS applications are extensive, including cargo logistics, and public journey entrance time calculation. The energy consumption of GPS based devices has been remained a research challenge for several past years (10), (11) and some energy saving strategies have been also presented (12). One method to detect devices using GPS is through a real-time differential location system and is presented in (13). The accuracy of the positioning availability can be improved by combining the multi-dimension position, which has many advantages, such as accuracy and continuity. Smart electronic devices based on IEEE 1588 protocol for GPS devices is proposed in (14). Furthermore, many GPS companies claim that their GPS devices can provide timing precision enhanced than one microsecond (12). GPS base Unmanned Aerial Vehicles (UAVs) control method base strategy is proposed in (15). In this case, the wind power UAV can be managed according to GPS signal.

On the other hand, now a day's researcher works on human behavior because the social network is made by the movement of a human. This problem is interdisciplinary academically. Big scale social networks are made by the people and this theory also confirms by sociological theory "Small World" (16, 17). Social awareness base solution is proposed and its technical issues are elaborated in (9). Mobile devices are moving every time along with the human being movement mostly by vehicle or walking, which devices make a social networking around.

Proposed device discovery in D2D communication is inspired by above-mentioned use cases. The first use case is peer to peer communication, in which proximity-based services are active. Peer to peer communication includes local voice and data communication, social networking, multiplayer games and context sharing. In a network assisted D2D communication, relay devices to exchange their information with base transceiver system (BTS) and then BTS transfer the information to the destination user. Devices send the reference signal and known synchronization signal sequences to identify the remote devices. In a network-assisted approach, network recognizes or discover the devices through paging or signaling and network act as an intermediate node to recognize the potential users, which qualify for D2D communication. In this approach, network synchronizes frequency and time for device discovery. BTS information helps to discover the accurate devices and enhance the efficiency of discovery.

Prior to the traffic broadcast, D2D discovery and access methodology is the first critical step which should be finished. GPS is inaccessible for indoor discovery in mobile-centric approach. In the network-centric approach, the discovery technique resides in the network instead of mobile. In this way, mobile, need not be altered and the system will be companionable with mobile currently in use. This approach has the greatest advantage over mobile-centric approach. In this paper, discovery method and access procedure are made for cellular systems using network-centric approach. We present GPS assisted and social aware base device discovery mechanism, where each node will send its current location to its base station. The base station will have a database for this positioning information. By using supposition criteria, the device will be classified to be capable of D2D communication. Our approach is to discover the devices in the cellular network using GPS parameters and neighbor awareness.

The rest of the paper is organized as follows: Section 2 presents the system model for device discovery procedure. Section 3 offers details of system simulation outcomes and analysis, while the paper is concluded with future work in Section 4.

2. System Model for Device Discovery Procedure

D2D Communication structure can be clarified by envisioning a two-level in 5G cellular structure, cell level communication, and device level communication. The cell level communication includes the base station involve as intermediate evolved Node B (eNB) as in a conventional cellular infrastructure. The device level includes D2D information sharing without the intermediate nodes (18). In any case, in the congested areas and at the cell edges, a specially appointed cross-section system is made and devices will be allowed to speak with one another.

In this research, D2D enabled network is assumed. There are two methods of which devices can be discovered; firstly, using eNB and secondly, using Core Network (CN). If the devices are in the same cell, then using eNB method devices can be discovered and completing the link procedure as shown in Figure 3. On the other hand, if the devices are in different cells then using CN information devices can be discovered and complete the like procedure as shown in Figure 4. GPS base position method is applicable both in eNB and CN.

If the devices are in multi-cell then CN will exchange the GPS information to their subcells. To initiate the device discovery and link procedure using CN, define steps are followed as shown in Figure 4. CN gathers the information from eNB on the request of users for D2D connection in different cells. This information contains the device identity, network types and resource information. If user-1 and user-2 qualify for D2D then CN initiates permission for link establishment. On the other hand, devices lie in a single cell then discovery will be through eNB. The discovery request message includes a device identity and a traffic type. GPS assisted base D2D discovery proposed architecture is given in Figure 5.

Database unit will be required in the conventional cellular network to store the current position of each mobile terminal. Location of each mobile terminal will be provided by the device or access to the network. From the location data, displacement metrics is calculated of mobile terminals in the operator vicinity by an algorithm. If the displacement metric between mobile terminals is in the paradigm range, then the D2D communication session will start. The supposition value between devices is 10m.

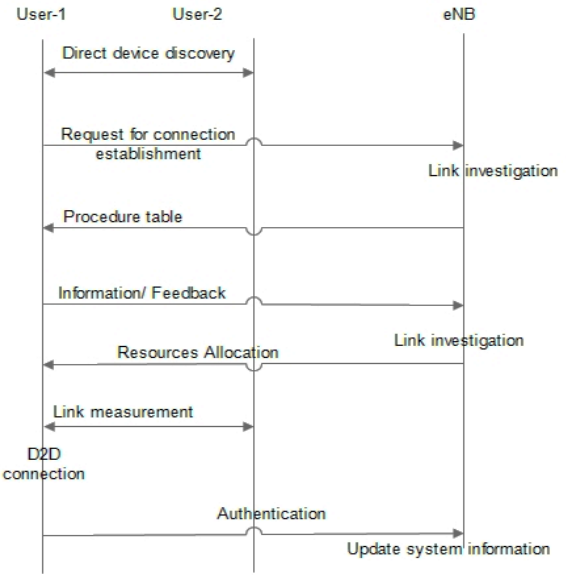


Fig. 3: Discovery and access procedure initiated by eNB

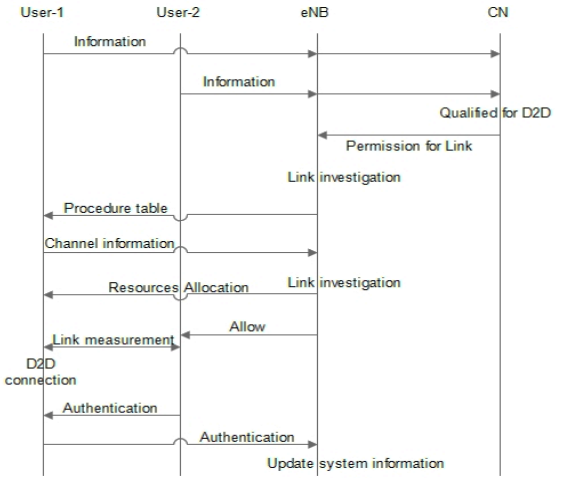


Fig. 4: Discovery and access procedure initiated by CN

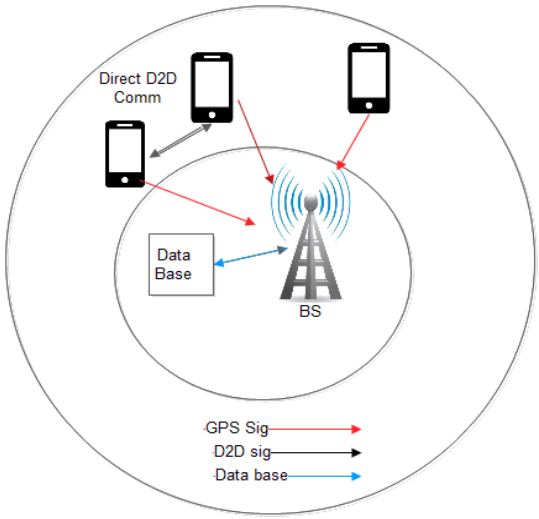


Fig. 5: Show the Proposed device discovery method

Spatial correlation of two devices can be expressed as x. Let x_a and x_b represent two devices separated by distance $d_a - d_b$. If the distance correlation lies in the supposition distance, then these two devices will qualify for D2D communication. The correlation of x_a and x_b which we symbolize $\rho(d_a - d_b)$, becomes

$$\rho(d_a - d_b) = E[x_a x_b] = e^{\left(-\frac{d_a - d_b}{d_{ref}}\right)} \quad (1)$$

In a network assisted D2D communication, users are fully controlled by the operators. Operator every time can take the position of the user even during handoff. At the same time, multiple devices are measured by the controlled network in D2D communication. A BTS monitors multiple devices in their vicinity and calculates the distance to find the precise location of the devices. BTS has a database unit which maintains the location record table. Many BTS are connected with CN which can also get information from different BTS's location record table and compare the result. BTS continually monitor the GPS signal to aware the position of devices and updates the location record table. Each GPS broadcast signal that includes; the sequence of ones and zeros (pseudo-random) PN code that is recognized by the receiver. By time aligning the receiver generated signal and receiver measured a signal of the PN code, the TOA (time of arrival) of a well-defined point in PN sequence can be found in the from receiver clock time. Also, PN sequence that includes TOT (Time of Transmission) of PN code at the BTS. Practically, BTS measures the TOTS and TOAs according to its own clock and then calculate the distance using 'Haversine' formula to compute the distance

$$a = \sin^2\left(\frac{\Delta\varphi}{2}\right) + \cos\varphi_1 . \cos\varphi_2 . \sin^2\left(\frac{\Delta\lambda}{2}\right) \quad (2)$$

$$c = 2.\operatorname{atan}2(\sqrt{a}, \sqrt{1-a}) \quad (3)$$

$$d = R.c \quad (4)$$

where λ is longitude, φ is latitude, R is earth radius. In practice, receiver location and the offset value of receiver clock comparative to GPS time are calculated instantaneously using navigation formula. When a device is static, then the position finding is easy once it starts giving the coordinates. Most of the receivers need to have tracking algorithms that associate measurements by different BTS. If the successive receiver closer to each other by measuring the distance, then they will qualify to communicate to each other. When new dimensions are gathered, the BTS apply weighting scheme to associate the new measurements using tracker prediction. In all-purpose, the tracker can increase the time accuracy, reject false measurements and also calculate direction and receiver speed. The Signal to Noise Ratio (SNR) at each device can be calculated as:

$$\mathrm{SNR_{dB}} = 10\log_{10}\left(\frac{\mathrm{P_s}}{\mathrm{Pn}}\right) \quad (5)$$

Where, P_s average power of the signal and P_n average power of the noise. As mention in (5), when the value of noise power becomes less, SNR value increases. Consequently, device reliability level will increase, and the discovery will be more reliable. In operator control, D2D communication same resources are used by D2D devices and conventional network users. It is much challenging to avoid the interference amongst cellular and D2D users. If there are no constraints for the D2D communication of using the frequency band, there will be adverse effect on cellular communication. Therefore, some robust discovery resource allocation systems are required to avoid the interference between D2D and conventional networks. Several factors affect resource allocation like radius of cell, distance between D2D users, transmission power, bandwidth, number of users and system resources like uplink and downlink.

3. Simulation Outcomes and Analysis

Differential code locates the devices and measures the signal to noise ratio of each device. G's are the gain ratio of each device if their gains are in threshold value then these devices are eligible for D2D communication. Figure 6 shows the random position of each device with their SNRs and positions. In this sky plot1, it can be seen that which devices are qualified for D2D communication.

[1] http://www.gogps-project.org

Device having gain G2 can make D2D communication with G5 by getting neighbor awareness of G10. 3D position view of each device east, north and their distances shown in Figure 7.

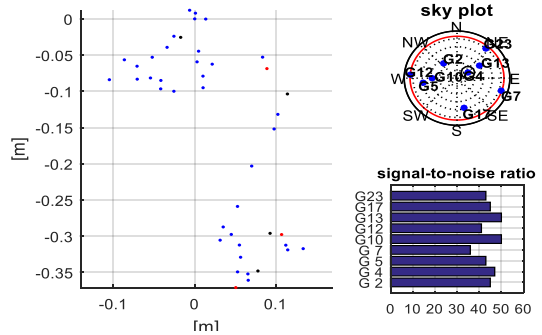


Fig. 6: Discovered devices with SNR, position, and distance in meters

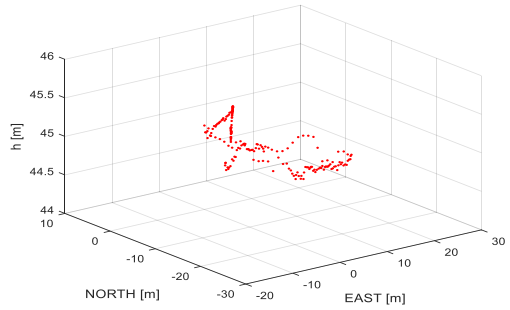


Fig. 7: Shows the 3D view of discovered devices

Figure 8 graphically tells how many devices are in which direction, position and epoch to discover the devices. Results show that using cooperative GPS and neighbor awareness method is much efficient than other techniques used in literature survey. Channel capacity of the femtocell is increased much time regarding Nano or Pico cell systems as shown in Figure 9.

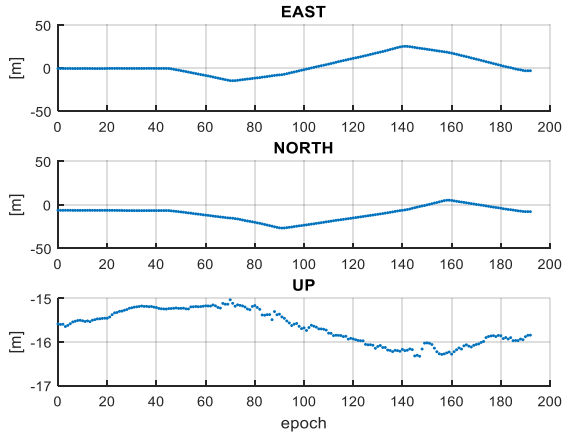


Fig. 8: Show the distances and epoch of discovered devices

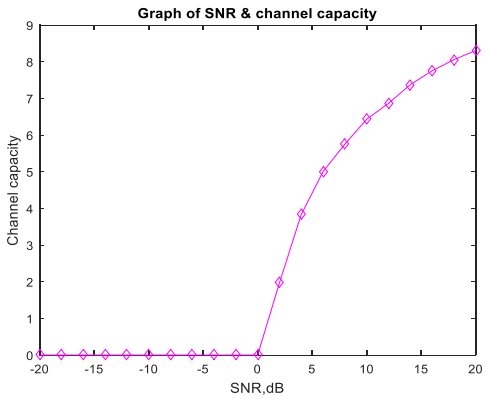


Fig. 9: SNR of discovered devices and channel capacity

4. Conclusion and Future work

In this work, we proposed a cooperative GPS and neighbor aware assisted base device discovery technique. Obtained results showed that our proposed technique can provide lower latency, efficient discovery in the high-density area, and accurate discovery in multiple femtocells in addition to capacity increment. In future works, results for multi-cell scenarios and neighbor awareness in no coverage zone will be obtained.

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